Comments on Docket No. NHTSA-2016-0068 and Docket ID No. EPA-HQ-OAR-2015-0827, *Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025*

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LBNL was contracted by DOE Vehicle Technologies Office to replicate the 2016 NHTSA regression analysis of the relationships between mass reduction and U.S. societal fatality risk per vehicle miles of travel (VMT). LBNL also conducted additional analyses to better understand the complicated relationship between mass or footprint reduction and fatality risk. LBNL worked closely with EPA and NHTSA on the compilation and analysis of the database used to estimate the relationship between vehicle mass and footprint and societal fatality risk per VMT. Many of the findings from these analyses are summarized in Chapter 8 of the Technical Assessment Report (TAR), with LBNL's full preliminary report included in the rulemaking docket for the TAR (Wenzel 2016a; NHTSA-2016-0068-0006 and EPA-HQ-OAR-2015-0827-0530). The most important findings are summarized below:

- confirmation of NHTSA's finding that mass reductions in all passenger cars are associated with small increases, while mass reductions in all light trucks and CUVs/minivans are associated with small decreases, in fatality risk per VMT (Figure 2.1 in Wenzel 2016a);

- based on NHTSA's jack-knife method to estimate uncertainties, none of these estimated effects are statistically significant at the 95% confidence level;

- the 2016 estimated effects of a reduction in car mass are essentially unchanged from the 2012 estimated effects; however, mass reduction in lighter-than-average light trucks is now associated with a slight reduction in fatalities (as opposed to an increase in fatalities in the 2012 analysis), while mass reduction in heavier-than-average light trucks and CUVs/minivans are associated with larger decreases in fatality risk than in the 2012 analysis (Figure 5.18 in Wenzel 2016a);

- the estimated effects of mass (or footprint) reduction on societal fatality risk are small, particularly compared to those from other vehicle, driver, and crash control variables included in the NHTSA baseline model (Figures 2.6 through 2.8 in Wenzel 2016a);

- an analysis of 246 popular vehicle models indicates that the correlation between vehicle mass and estimated societal fatality risk is low, even after accounting for other vehicle, driver, and crash factors (Figures 4.6 and 4.7 in Wenzel 2016a). For example, societal fatality risk varies by about a factor of two across 4-door car models of similar mass, and one 4-door car model has the same societal risk as models weighing at least 1,500 pounds more (Figure 4.9 in Wenzel 2016a);

- an analysis of the 10 most popular 4-door car models over time, which accounts for differences in the characteristics and behavior of drivers of particular vehicle models, suggests that annual increases in mass from redesign/refresh of a car model is not consistently associated with a reduction in societal fatality risk, and that reductions in fatality risk can occur in the absence of increases in mass (Figures 3 and 7 in Wenzel 2016b);

- NHTSA ran a regression model with all of the control variables except footprint, for each crash and vehicle type, and footprint decile, a total of 270 regression models, using a single mass variable for all three types of vehicles. Reducing vehicle mass does not consistently increase risk across all footprint deciles for any combination of vehicle type and crash type. Risk increases with decreasing mass in a majority of footprint deciles for only 11 of the 27 crash and vehicle combinations, but few of these increases are statistically significant. On the other hand, risk decreases with decreasing mass in a majority of footprint deciles for 10 of the 27 crash and vehicle combinations; in some cases these risk reductions are large and statistically significant. These findings confirm that the effect of mass reduction while holding footprint constant, if any, is small (Table 3.2 in Wenzel 2016a).

- an analysis using multiple bins of curb weight for cars and light trucks (rather than the two bins NHTSA used in its baseline model) suggests that the relationship between mass reduction and societal fatality risk is not consistent over the range in vehicle mass (Figures 6 and 7 in Wenzel 2016c)

- the estimated relationships between mass reduction and societal fatality risk from NHTSA's baseline regression model are sensitive to the data and variables used (Tables 5.14 and 5.15 in Wenzel 2016a). For example, excluding three sporty car models (similar to the muscle car models NHTSA excluded in the baseline model) from the regression analysis reduces the estimated increase in fatality risk from mass reduction in cars.

- an alternative model specification recommended by DRI (Van Auken and Zellner 2013) results in a smaller increase in fatality risk in lighter-than-average cars, larger decreases in fatality risk in heavier-than-average cars and light trucks, and a smaller decrease in fatality risk in CUVs/minivans, than the NHTSA baseline model (Figure 5.19 in Wenzel 2016a);

- an alternative model specification suggested by LBNL results in an even smaller increase in fatality risk in lighter-than-average cars, larger decreases in fatality risk in heavier-than-average cars and light trucks, and a smaller decrease in fatality risk in CUVs/minivans, than the NHTSA baseline or DRI recommended models (Figure 5.19 in Wenzel 2016a);

- the fleet mass reduction recommended in the 2015 NRC fuel economy subcommittee report would result in large decreases in fatalities, regardless of whether the baseline NHTSA, DRI, or LBNL regression coefficients are used (Scenario 6 in Table 6.2 in Wenzel 2016a);

Because the estimated relationships between mass reduction and societal fatality risk are not consistently statistically different from zero, and are sensitive to the data and variables used in the regression models, LBNL recommends that the agencies use a second set of regression coefficients, such as those used in the "LBNL baseline", that estimate the relationship between mass reduction and societal fatality risk. This second set of coefficients can be used as a sensitivity test when determining the extent to which manufacturers can use mass reduction as a strategy to meet fuel economy/GHG emission standards while minimizing costs in the NHTSA Volpe and EPA OMEGA models.

Although LBNL believes that the current analysis is the most comprehensive and thorough investigation to date of the relationship between vehicle mass/footprint and safety, there are limitations to the analysis. While the goal of the NHTSA and LBNL reports is to estimate the effect of vehicle mass reduction on societal risk, they are actually estimating the recent historical relationship between mass and risk, after accounting for most measurable differences between vehicles, drivers, and crash times and locations. In other words, they are comparing the risk of a 2600-lb Dodge Neon with that of a 2500-lb Honda Civic, after attempting to account for all other differences between the two vehicles, rather than estimating the effect of literally removing 100 pounds from the Neon leaving everything else unchanged. In addition, the analyses are based on the relationship of vehicle mass and footprint on risk for recent vehicle designs (model year 2003 to 2010); these relationships may or may not continue into the future as manufacturers utilize new vehicle designs and incorporate new technologies, such as more extensive use of strong lightweight materials and specific safety technologies. As a result, the agencies should recognize that the findings from the regression analyses of the recent historical relationship between vehicle mass and fatality risk cannot accurately predict what effect mass reduction in future vehicle designs will have on societal fatality risk, especially in light of extensive use of stronger lightweight materials and adoption of new crash prevention technologies.

References

Van Auken, R.M., and Zellner, J. W. 2013. *Updated Analysis of the Effects of Passenger Vehicle Size and Weight on Safety; Sensitivity of the Estimates for 2002 to 2008 Calendar Year Data for 2000 to 2007 Model Year Light Passenger Vehicles vs. Induced-Exposure Data and Vehicle Size Variables*. Prepared for the International Council on Clean Transportation, The Energy Foundation, and American Honda Motor Company. Dynamic Research, Inc.: Torrance, CA May. DRI-TR-13-04 and Docket No. NHTSA-2010-0152-0064.

Wenzel, Tom. 2016a. *Assessment of NHTSA's Report "Relationships Between Fatality Risk, Mass, and Footprint in Model Year 2003-2010 Passenger Cars and LTVs".* Preliminary report prepared for the Office of Energy Efficiency and Renewable Energy, US Department of Energy. Lawrence Berkeley National Laboratory: Berkeley, CA. June. LBNL-1005177 and Docket Nos. NHTSA-2016-0068-0006 and EPA-HQ-OAR-2015-0827-0530.

Wenzel, Tom. 2016b. *Relationship between US Societal Fatality Risk per Vehicle Miles of Travel and Mass, for Individual Vehicle Models over Time (Model Year).* Final report prepared for the Office of Energy Efficiency and Renewable Energy, US Department of Energy. Lawrence Berkeley National Laboratory: Berkeley, CA. July. LBNL-1006316.

Wenzel, Tom. 2016c. *Effect of using Different Vehicle Weight Groups on the Estimated Relationship between Mass Reduction and U.S. Societal Fatality Risk per Vehicle Miles of Travel.* Final report prepared for the Office of Energy Efficiency and Renewable Energy, US Department of Energy. Lawrence Berkeley National Laboratory: Berkeley, CA. August. LBNL-1006317.

Figure 2.1. Estimated effect of mass or footprint reduction on US societal fatality risk per VMT, from NHTSA baseline model, by vehicle type

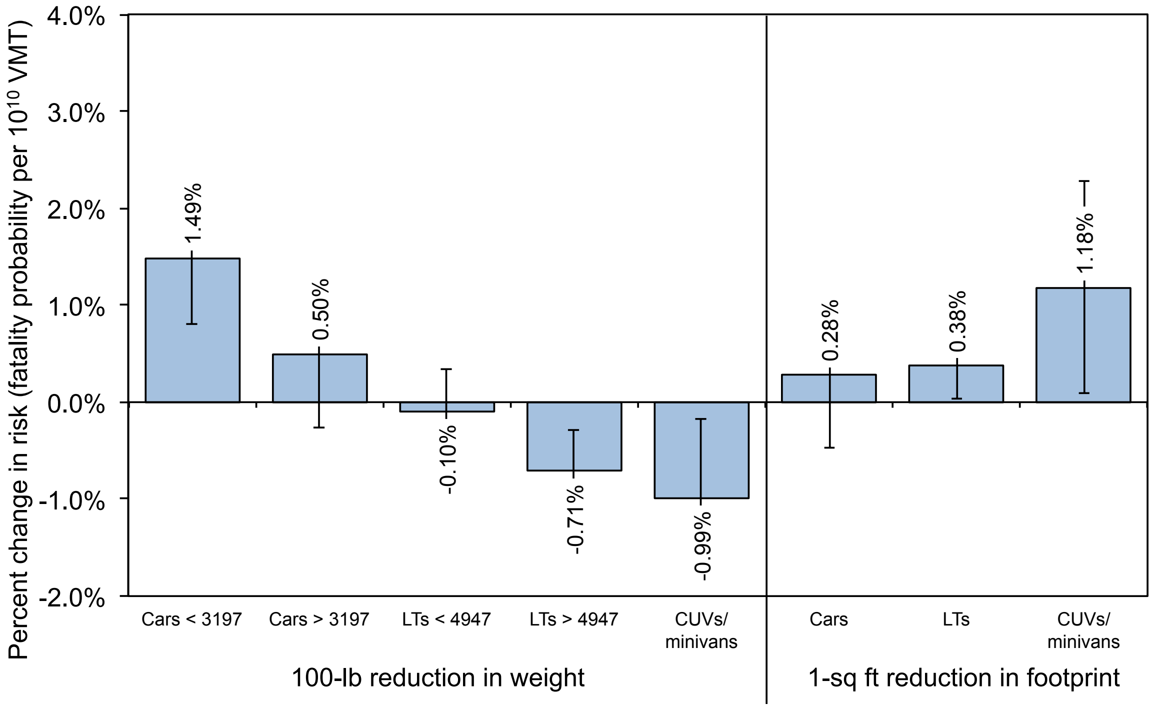

Figure 5.18. Estimated effect of mass reduction on US fatality risk per VMT by vehicle type, from NHTSA baseline models in 2003, 2012, and 2016 analyses

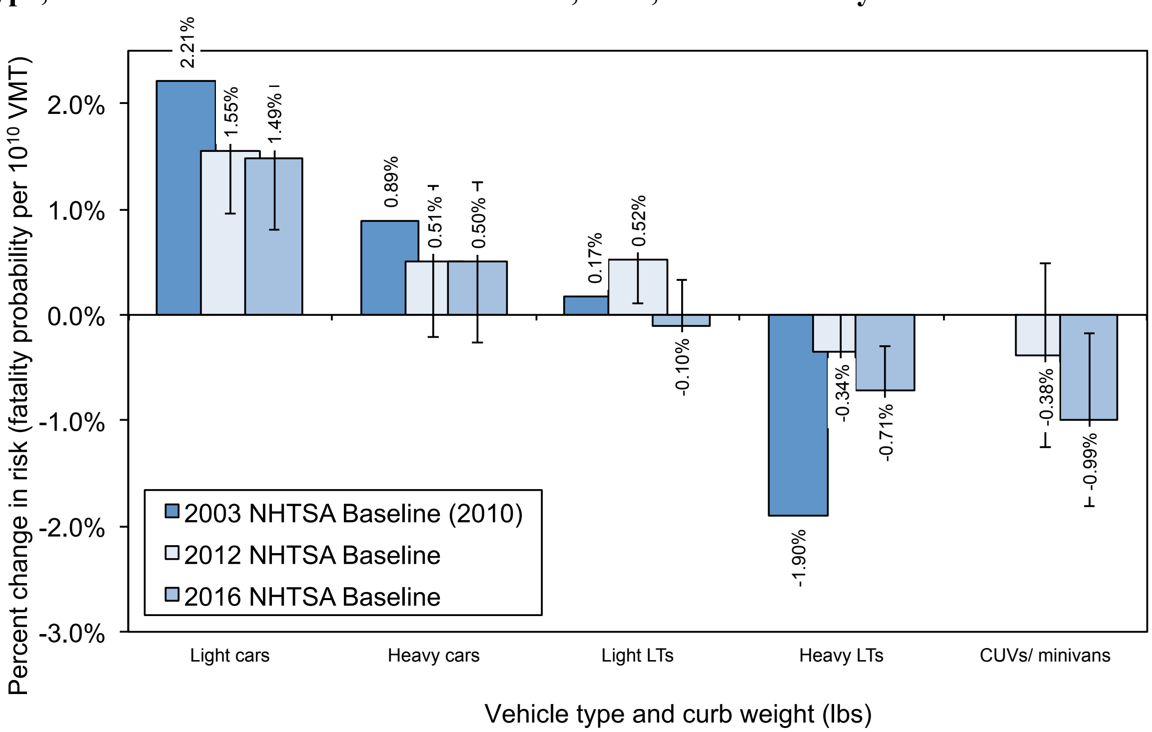

Figure 2.6. Estimated effect of selected control variables on risk, passenger cars

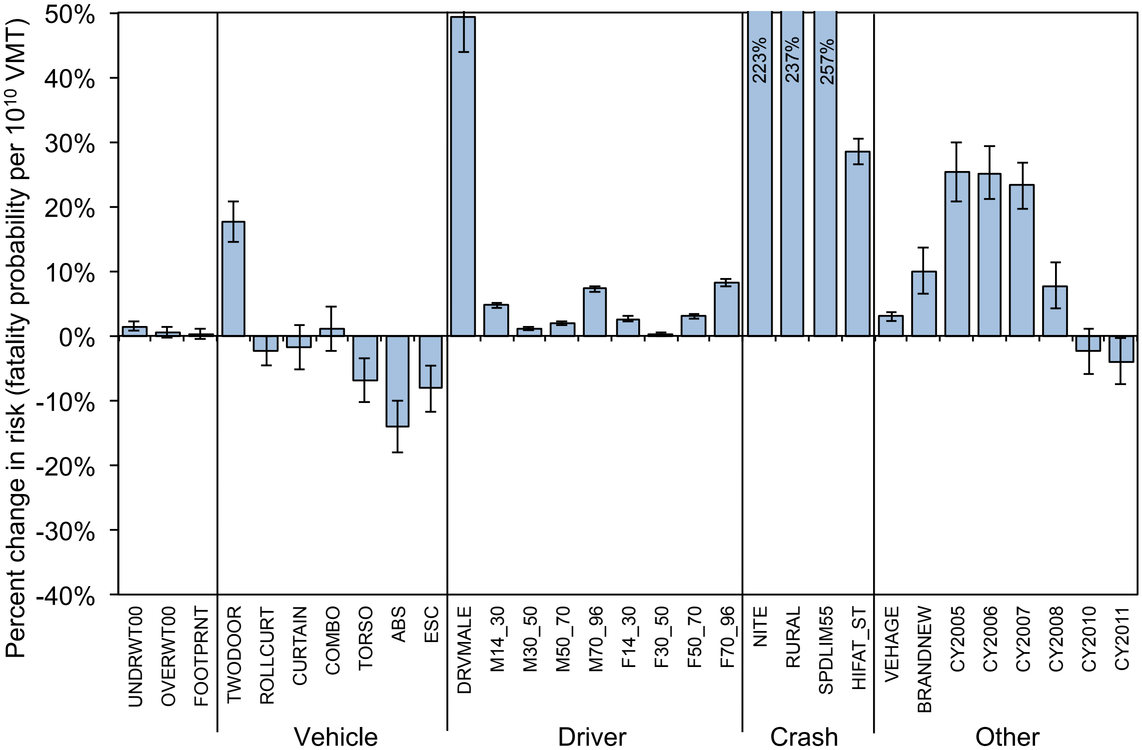

Figure 2.7. Estimated effect of selected control variables on risk, light trucks

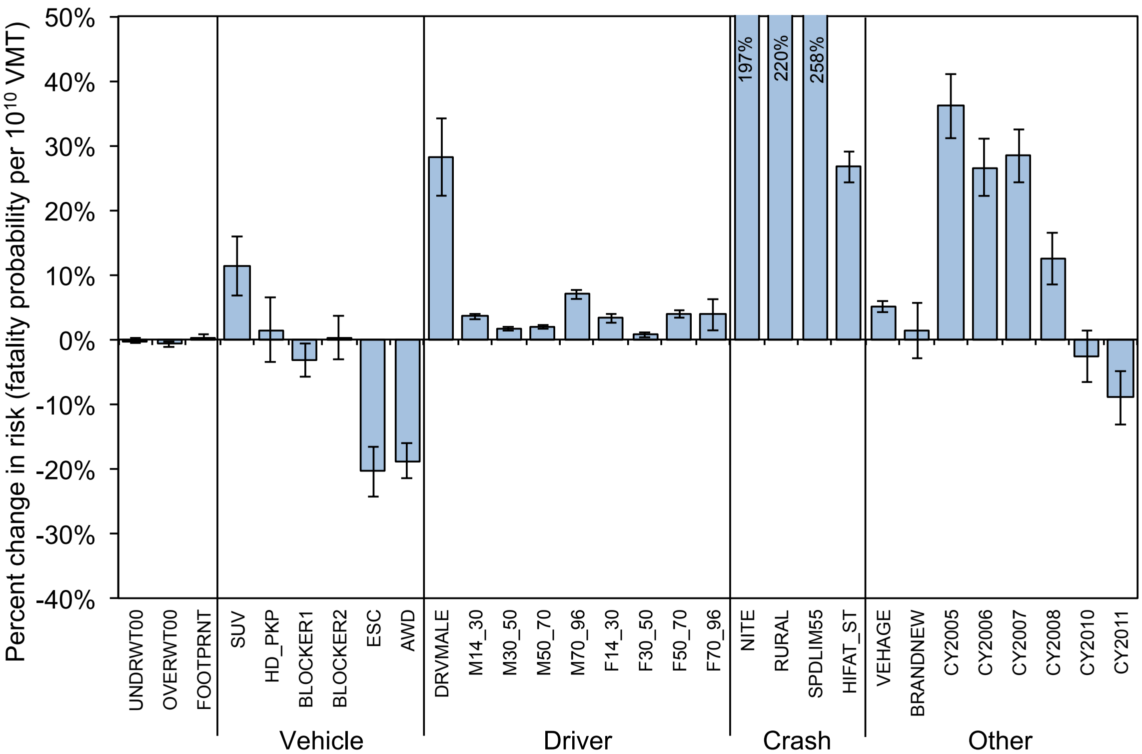

Figure 2.8. Estimated effect of selected control variables on risk, CUVs and minivans

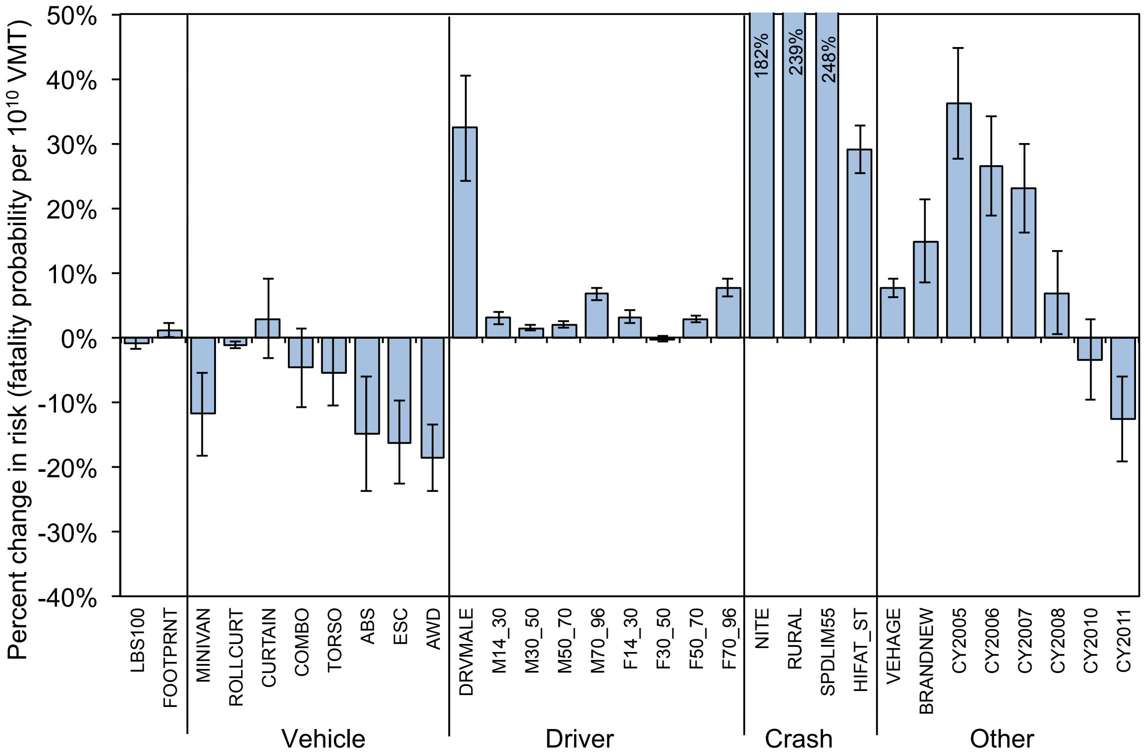

Figure 4.6. Actual US societal fatality risk per VMT and curb weight, by vehicle model

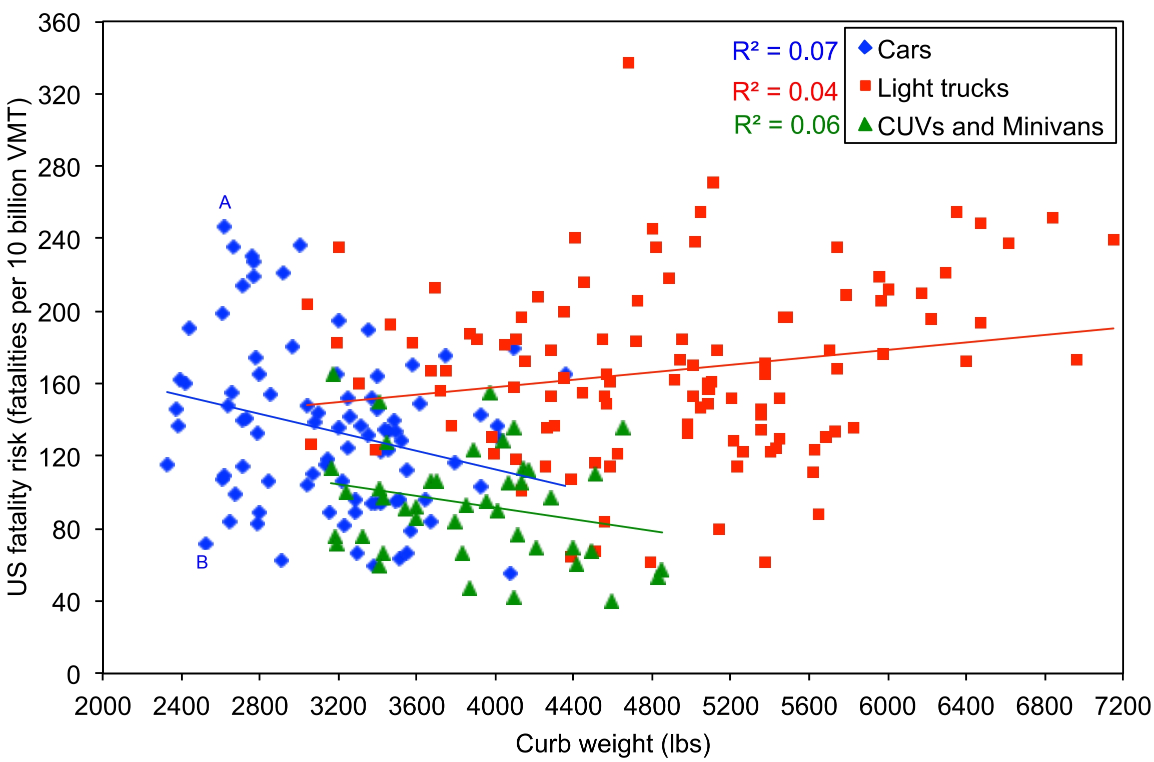

Figure 4.7. Adjusted US societal fatality risk per VMT after accounting for all driver, crash, and vehicle variables except mass and footprint, vs. curb weight

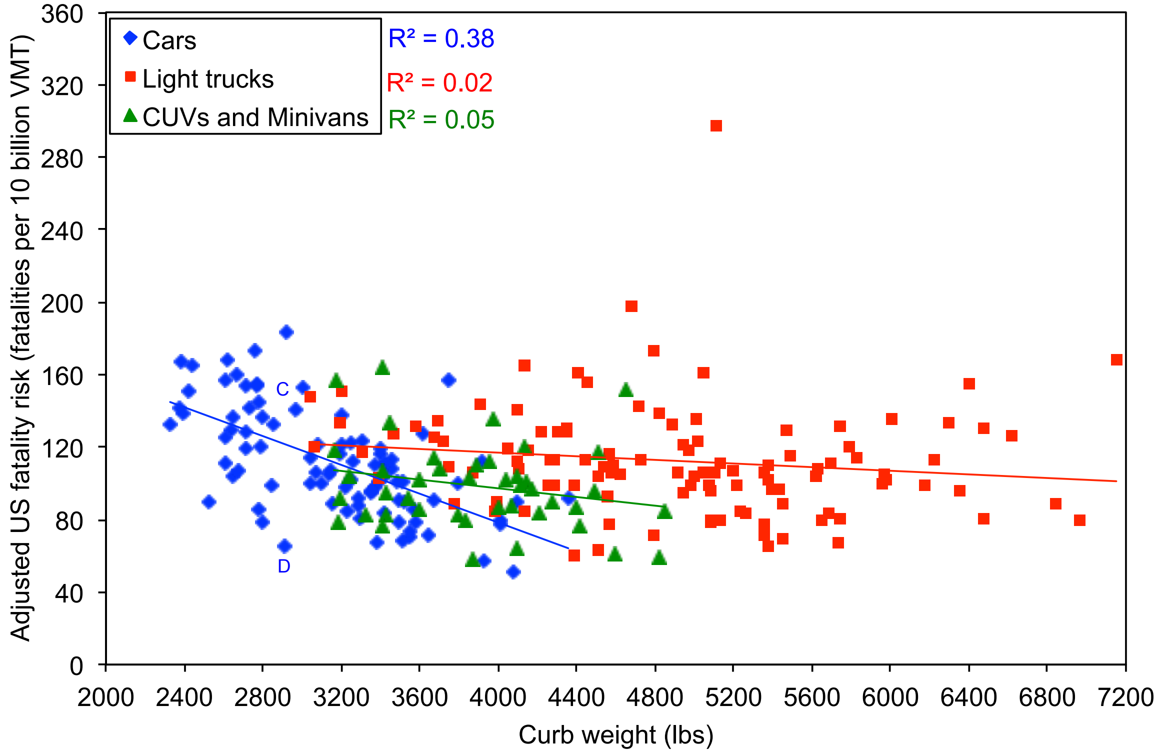

Figure 4.9. Adjusted US societal fatality risk per VMT after accounting for all driver, crash, and vehicle variables except mass and footprint vs. curb weight, car models

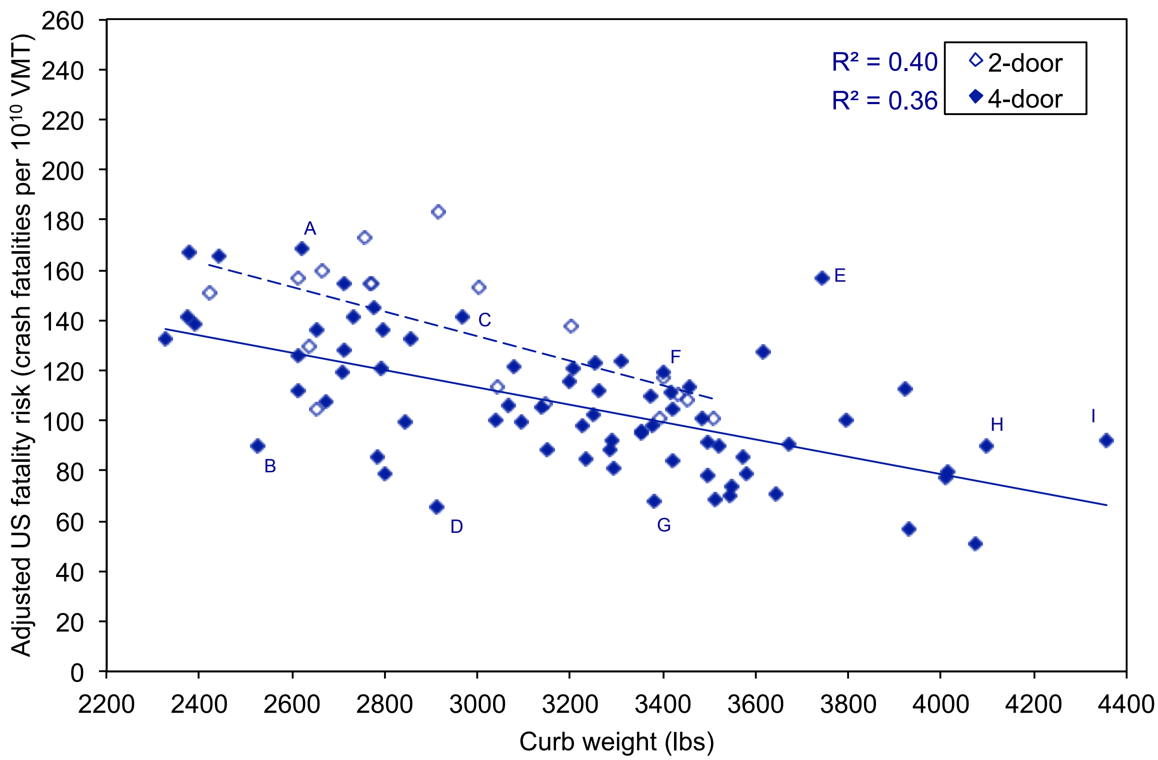

Figure 3. Trend in US societal fatality risk per VMT vs. mass over time (by model year), for 10 most-popular four-door car models

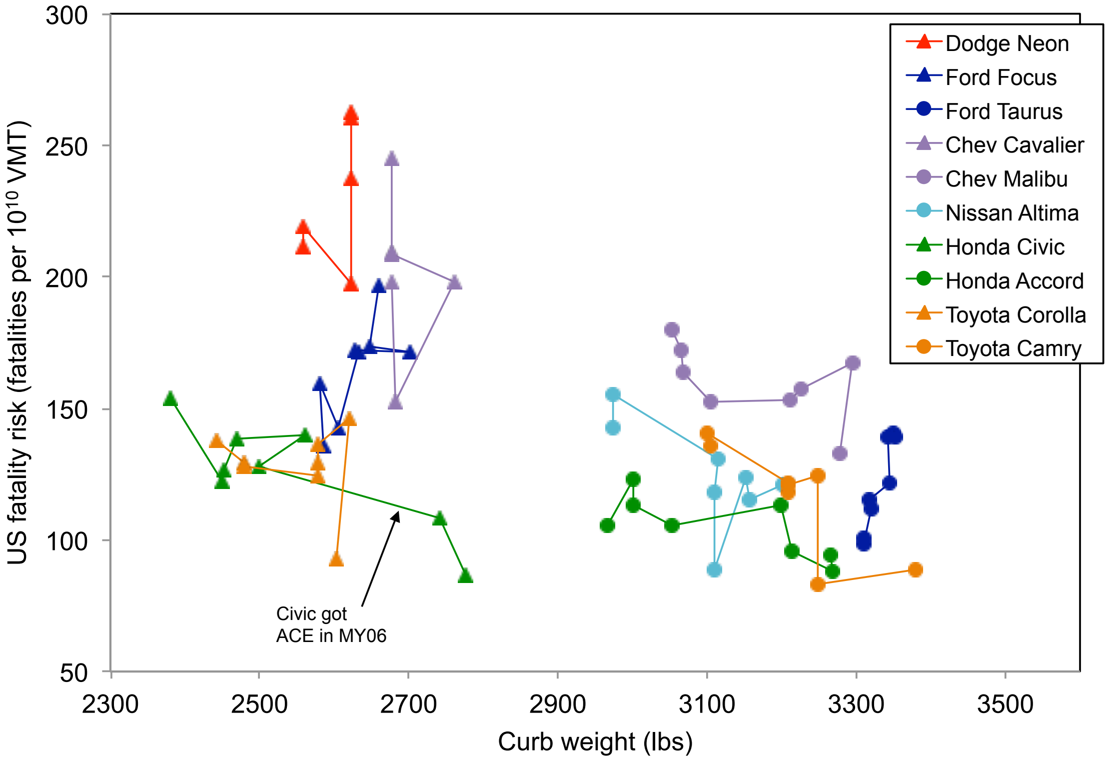

Figure 7. Updated trend in US societal fatality risk per VMT vs. mass over time (by model year), for 10 most-popular four-door car models

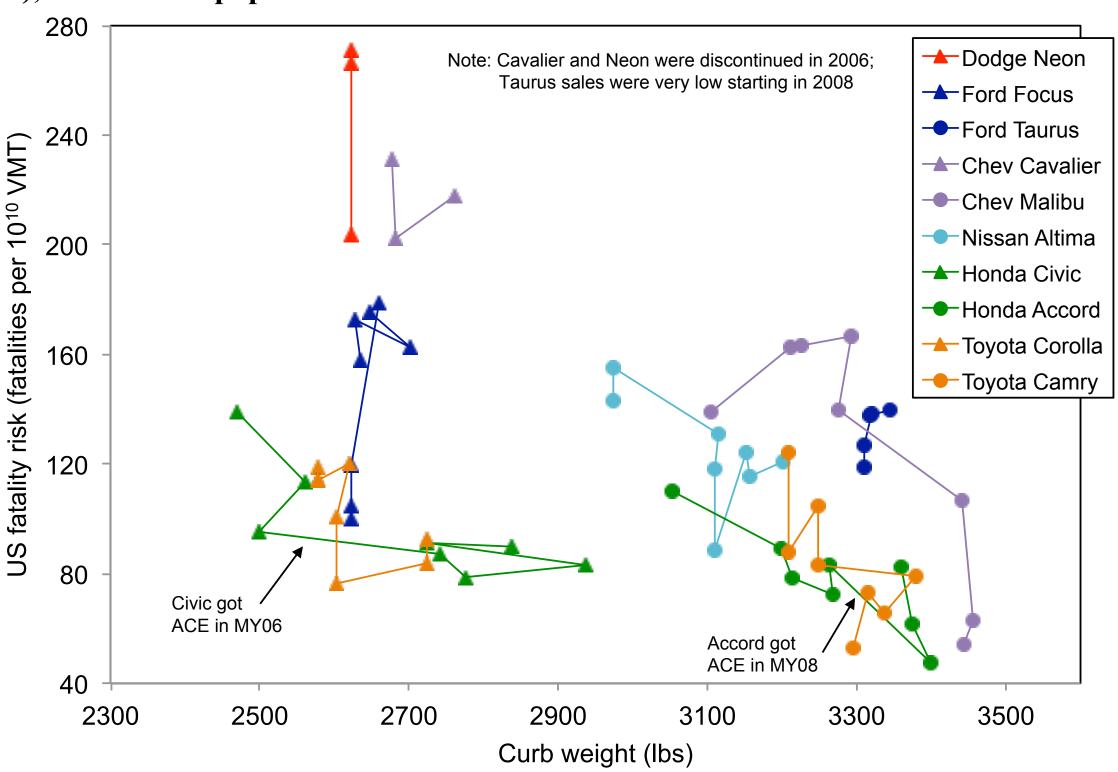

Table 3.2. Number of footprint deciles in which lower vehicle mass is associated with an increase or decrease in US fatality risk by VMT, by vehicle and crash type

Crash type	Cars				Light trucks				CUVs/Minivans			
	Number of deciles with increasing risk	Number of deciles with estimates that are statistically significant	Number of deciles with decreasing risk	Number of deciles with estimates that are statistically significant	Number of deciles with increasing risk	Number of deciles with estimates that are statistically significant	Number of deciles with decreasing risk	Number of deciles with estimates that are statistically significant	Number of deciles with increasing risk	Number of deciles with estimates that are statistically significant	Number of deciles with decreasing risk	Number of deciles with estimates that are statistically significant
1: Rollovers	3	0	7	2	7	2	3	3	4	0	6	2
2: w/object	5	0	5	1	5	1	5	1	5	2	5	1
3: w/ped etc.	5	2	5	1	5	0	5	0	4	0	6	0
4: w/HDT	6	0	4	0	8	2	2	0	6	1	4	1
5: w/lgt car	3	0	7	1	4	2	6	3	7	1	3	0
6: w/hvy car	6	2	4	0	3	1	7	2	7	1	3	0
7: w/lgt LT	2	0	8	1	3	0	7	1	4	2	6	0
8: w/hvy LT	6	2	4	0	5	0	5	1	6	0	4	0
9: Other	6	2	4	0	6	1	4	2	4	0	6	0

Note: Cases in which three or more footprint deciles have significant coefficients are highlighted in yellow.

Figure 6. Estimated effect of car mass reduction on US societal fatality risk per VMT, baseline model and six alternative weight groups

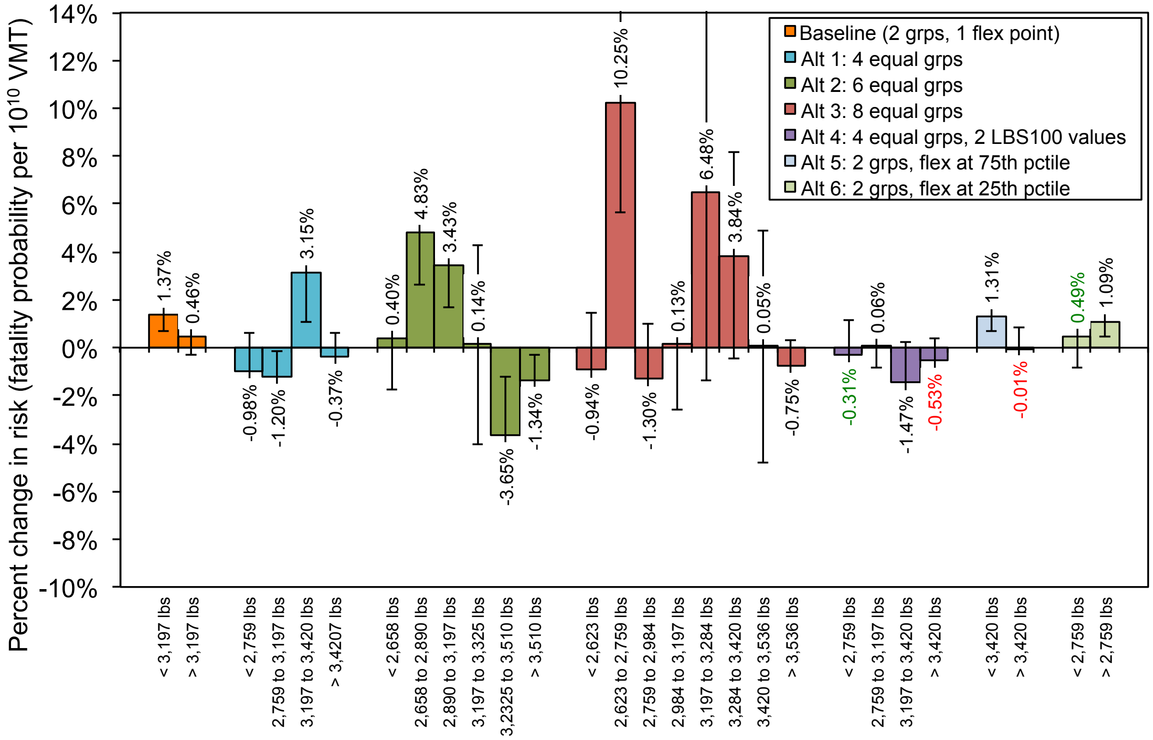

Figure 7. Estimated effect of light truck mass reduction on US societal fatality risk per VMT, baseline model and six alternative weight groups

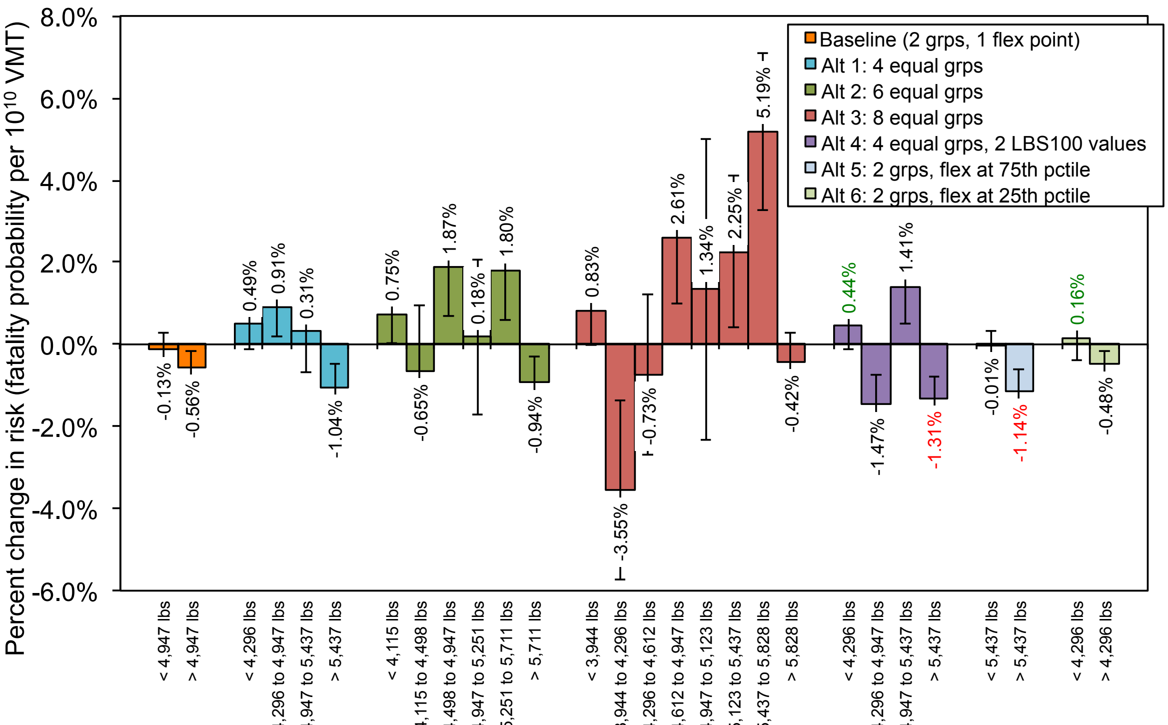

Table 5.14. Description of 33 alternative regression models analyzed in this report

Alternate measure of risk	1.Weighted by current distribution of fatalities (rather than after 100% ESC) 2.Single regression model across all crash types (rather by crash type) 3.Fatal crashes (rather than fatalities) per VMT 4.Fatalities per induced exposure crash (rather than VMT) 5.Fatalities per registered vehicle-year (rather than VMT)
Alternate control variables or data	6.Allow footprint to vary with mass (and vice versa) 7.Account for 14 vehicle manufacturers 8.Account for 14 manufacturers + 5 additional luxury vehicle brands 9.Account for initial vehicle purchase price (based on Polk VIN decoder) 10.Exclude CY variables 11.Exclude crashes with alcohol/drugs 12.Exclude crashes with alcohol/drugs, and drivers with poor driving record 13.Account for median household income 14.Include sports, police, and all-wheel drive cars, and full size vans
Proposed by DRI/ reviewers	15.Use stopped instead of non-culpable vehicles for induced exposure 16.Replace footprint with track width and wheelbase 17.Above two models combined (15 and 16) 18.Reweight CUV/minivans by 2010 sales 19.Exclude non-significant control variables
New alternatives analyzed in this report	20.Exclude LTs over 10k GVWR[1] 21.Small pickups and SUVs[1] 22.Large pickups[1] 23.Above two models combined for large pickups[1] (20 and 22) 24. Include AWD cars, but not muscle or police cars 25. Include muscle and police cars, but not AWD cars 26. Exclude three high-risk car models 27. Include AWD cars, exclude three high-risk car models (24 and 26) 28. Two-piece variable for CUV mass[2] 29. Two-piece variable for PC and LT footprint[3] 30. Two-piece variable for CUV mass, and for all footprint[3] (28 and 29) 31. Remove kinks in NHTSA VMT schedules 32. Use Texas rather than Polk odometer ratios 33. Both adjustments to NHTSA VMT weights (31 and 32)

[1] The median weights used for Models 20-23 are: 4,870 pounds for Model 20; 4,704 pounds for Model 21; 6,108 pounds for Model 22; and 6,062 pounds for Model 23.

[2] The median weight used for CUVs/minivans in Models 28 and 30 is 3,939 pounds.

[3] The median footprints used for Models 29 and 30 are 44.3 square feet for cars, 56.9 square feet for light trucks, and 49.0 square feet for CUVs/minivans.

Table 5.15. Estimated effect of mass or footprint reduction on US fatalities, baseline and 33 alternative regression models analyzed in this report

	Model	Mass reduction: Cars <3197 lbs	Mass reduction: Cars ≥3197 lbs	Mass reduction: Light trucks <4947 lbs	Mass reduction: Light trucks ≥4947 lbs	Mass reduction: CUV/ minivan	Footprint reduction: Cars	Footprint reduction: Light trucks	Footprint reduction: CUV/ minivan
	Baseline	1.49%	0.50%	-0.10%	-0.71%	-0.99%	0.28%	0.38%	1.18%
Alternate risk definitioin	1	1.37%	0.46%	-0.13%	-0.56%	-1.30%	0.47%	0.53%	1.75%
	2	1.36%	0.46%	-0.13%	-0.56%	-1.31%	0.46%	0.53%	1.73%
	3	1.67%	0.58%	-0.02%	-0.72%	-1.28%	0.45%	0.38%	1.82%
	4	1.14%	-0.85%	-1.66%	-1.06%	-0.16%	1.17%	-0.66%	0.34%
	5	1.45%	2.90%	-0.56%	-1.24%	-0.42%	-1.59%	0.29%	-0.26%
Alternate control variables or data	6	1.71%	0.68%	0.26%	-0.55%	-0.25%	1.44%	0.13%	0.08%
	7	2.39%	1.37%	0.32%	-0.09%	0.00%	0.39%	-0.09%	-0.02%
	8	2.65%	2.96%	0.30%	0.00%	-0.43%	-0.33%	-0.10%	0.63%
	9	1.42%	0.70%	-0.39%	-0.99%	-1.65%	0.26%	0.23%	1.11%
	10	0.53%	0.10%	-0.10%	-0.52%	-1.13%	1.02%	0.44%	1.31%
	11	2.08%	1.09%	0.21%	-0.83%	-1.01%	-0.02%	0.16%	1.12%
	12	2.72%	1.57%	0.42%	-0.55%	-1.00%	-0.04%	-0.07%	1.35%
	13	1.42%	-0.11%	-0.08%	-0.62%	-1.43%	1.04%	0.32%	1.70%
	14	1.44%	0.62%	-0.05%	-0.94%	-0.99%	0.32%	0.34%	1.18%
Suggested by reviewers	15	1.58%	-0.42%	-0.09%	-1.80%	-0.61%	1.02%	0.51%	0.66%
	16	0.93%	0.48%	-0.66%	-0.97%	-1.15%	—	—	—
	17	0.88%	-0.43%	-0.85%	-2.13%	-0.66%	—	—	—
	18	1.49%	0.50%	-0.10%	-0.71%	-0.27%	0.28%	0.38%	0.40%
	19	1.47%	0.54%	-0.13%	-0.70%	-0.84%	0.30%	0.41%	1.14%
New alternatives analyzed in this report	20[1]	1.49%	0.50%	0.06%	-0.80%	-0.99%	0.28%	0.29%	1.18%
	21[1]	1.49%	0.50%	-0.01%	-0.24%	-0.99%	0.28%	0.30%	1.18%
	22[1]	1.49%	0.50%	-4.27%	0.52%	-0.99%	0.28%	0.60%	1.18%
	23[1]	1.49%	0.50%	-6.49%	1.31%	-0.99%	0.28%	0.42%	1.18%
	24	1.29%	0.77%	-0.10%	-0.71%	-0.99%	0.35%	0.38%	1.18%
	25	1.66%	0.40%	-0.10%	-0.71%	-0.99%	0.24%	0.38%	1.18%
	26	1.38%	0.29%	-0.10%	-0.71%	-0.99%	0.42%	0.38%	1.18%
	27	1.15%	0.53%	-0.10%	-0.71%	-0.99%	0.51%	0.38%	1.18%
	28[2]	1.49%	0.50%	-0.10%	-0.71%	-0.31% -1.21%	0.28%	0.38%	0.90%
	29[3]	1.31%	0.72%	-0.75%	-0.89%	-1.07%	0.78% -0.10%	1.62% -0.10%	1.67% 0.67%
	30[2,3]	1.31%	0.72%	-0.75%	-0.89%	-0.20% -1.21%	0.78% -0.10%	1.62% -0.10%	0.88% 0.80%
	31	1.47%	0.49%	-0.10%	-0.72%	-0.99%	0.29%	0.38%	1.18%
	32	1.21%	0.15%	-0.25%	-0.87%	-0.99%	0.73%	0.84%	1.03%
	33	1.19%	0.13%	-0.26%	-0.87%	-1.00%	0.74%	0.84%	1.03%

Red font indicates estimate is statistically significant at 95% confidence interval. Gray shading indicates estimate is not changed from baseline regression model in alternative regression model.

[1] The median weights used for Models 20-23 is: 4,870 pounds for Model 20; 4,704 pounds for Model 21; 6,108 pounds for Model 22; and 6,062 pounds for Model 23.

[2] The two estimates for CUV/minivan mass in Models 28 and 30 are for vehicles under and over the median mass (3,939 pounds).

[3] The two estimates for footprint are for vehicles under and over the median footprint (44.3 square feet for cars, 56.9 square feet for light trucks, and 49.0 square feet for CUVs/minivans).

Figure 5.19. Estimated effect of mass reduction on US fatality risk per VMT by vehicle type, NHTSA baseline, DRI measures, and LBNL baseline

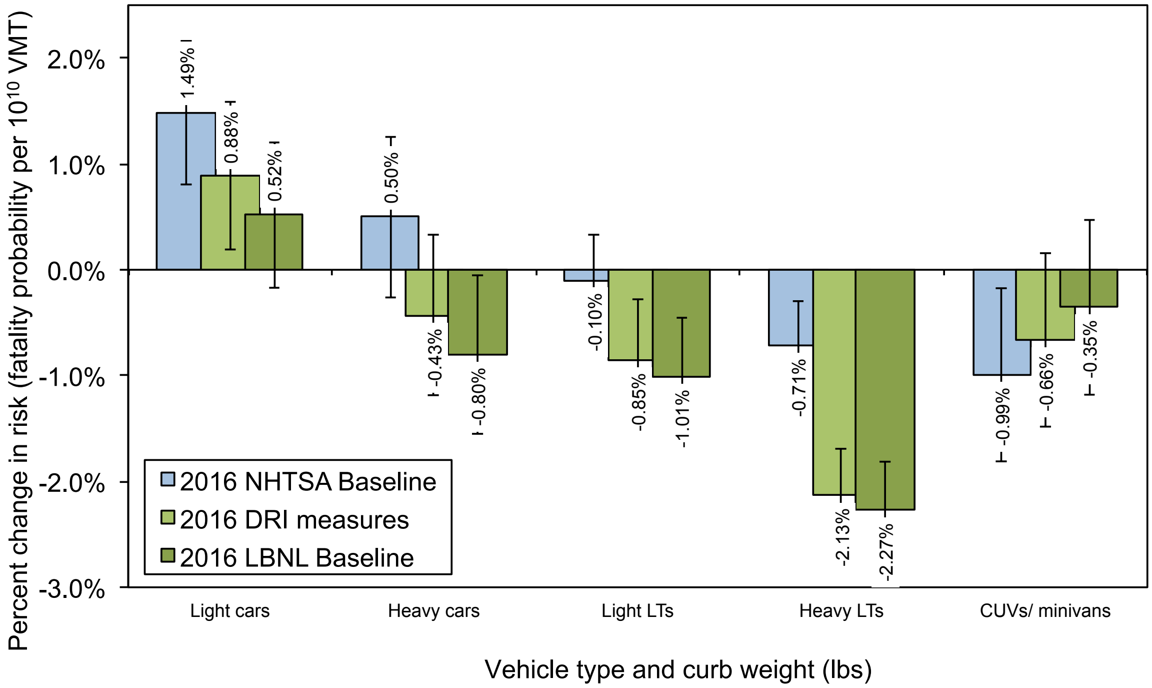

Table 6.2. Estimated annual change in fatalities from six different fleetwide mass reduction scenarios, using coefficients estimated by NHTSA baseline, DRI measures, and LBNL baseline models

Coefficients used	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
NHTSA	91	36	-93	0	-776	-344
DRI	-159	-227	-442	-289	-3017	-1958
LBNL	-208	-268	-475	-328	-3284	-2079